Joint optimisation of regional energy and CCS infrastructure systems of Morocco, Portugal and Spain: the TIMES-COMET model

Amit Kanudia, Maryse Labriet, Maurizio Gargiulo, GianCarlo Tosato *(gctosato@tiscali.it)*

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Outline

1. Modelling objectives and research questions
2. The TIMES-CCS model
3. The composition of the TIMES-COMET model
4. TSviewer: geographical presentation of the results

1. Introduction: modelling objectives of the research

The work package on modelling and scenarios aims at (more on the COMET project: http://comet.lneg.pt) :

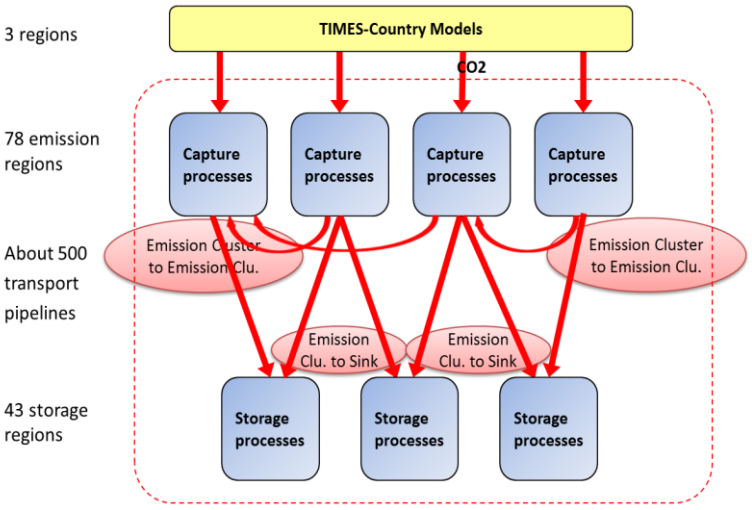
1. Analysing the present energy system of Morocco, Portugal & Spain with a mainly technological point of view
2. Representing the systems and their possible long term developments with technical-economic models
3. Representing in a technical-economic model with spatial detail the geo-referenced CO2 emission and storage points, connected by a network of transport infrastructures
4. Building CCS infrastructure scenarios for the Iberian – Morocco system for the assessment of CCS in the national portfolio of mitigation measures
5. Suggesting cost effective CO2 source-sinks combinations, according to different development and objective assumptions

1. Introduction: research questions …

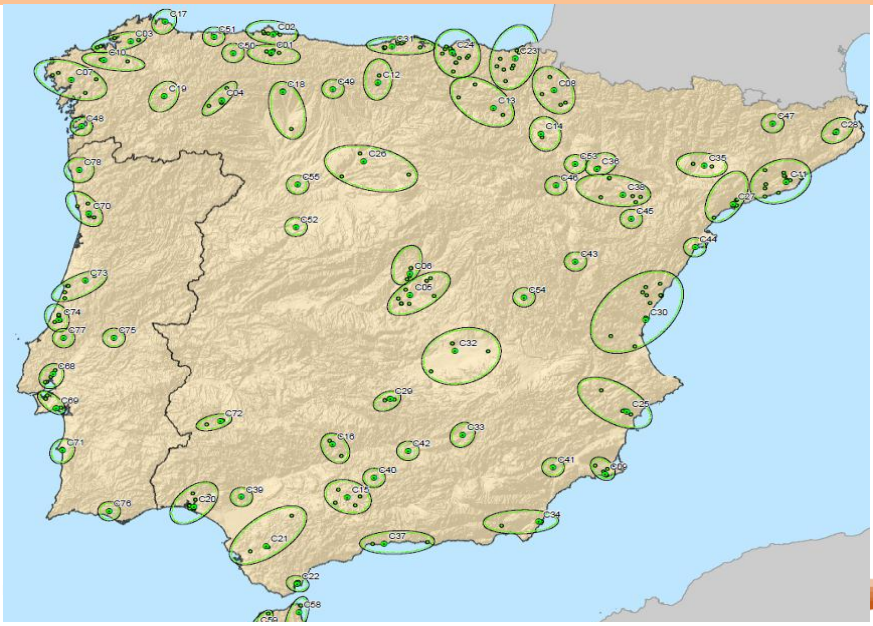
… in the field of modelling and scenario building:

- ***Is it possible to represent in a single (hard-linked) bottom-up economic model the technological details of energy systems and the geographical details of a CCS infrastructure system?***
- Is it worth? What does it add to the studies making use of separate models?
- Is it possible to represent in a single (hard-linked) bottom-up model the national energy technology systems with continuous variables and the capacity of CO2 pipelines with integer variables?
- Is it worth? What does it add to the studies making use of separate models?
- What scientific-economic conditions make it necessary the development and implementation of CCS because the other mitigation options appear not sufficient?

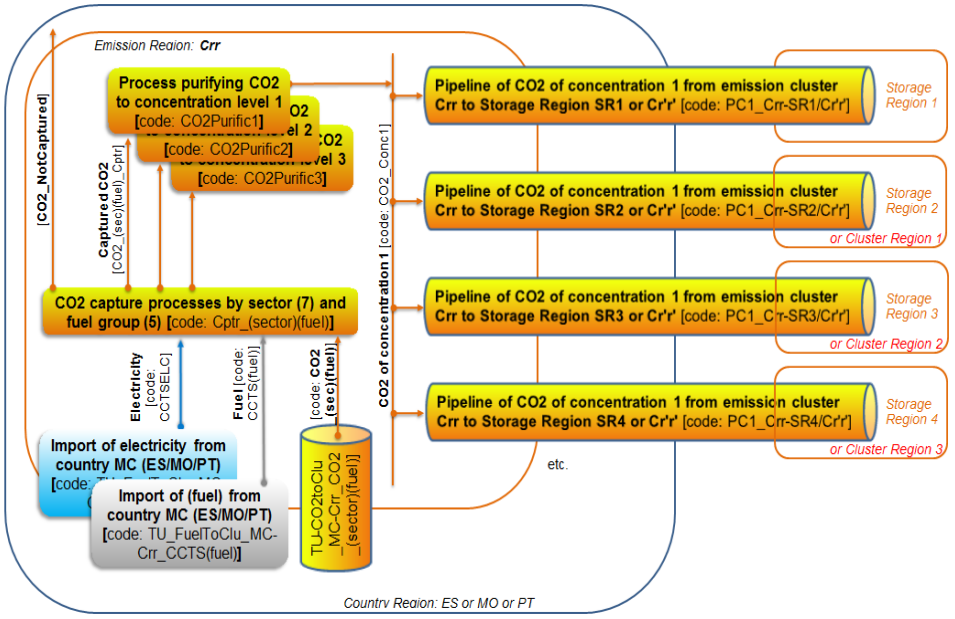
2. Block diagram of the TIMES-CCS model



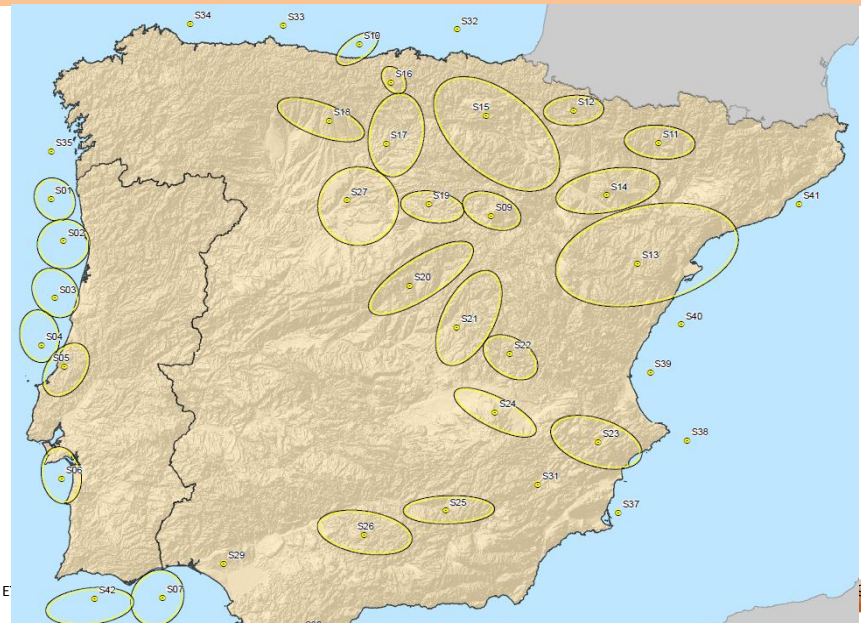
2.1 Emission sources: location of 78 clusters



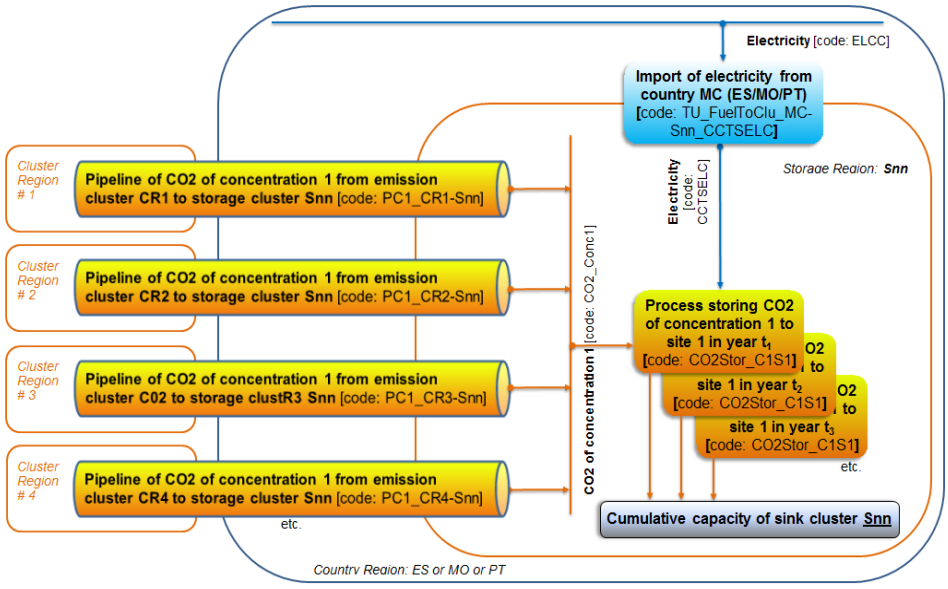
2.1 Emission cluster regions: capture model



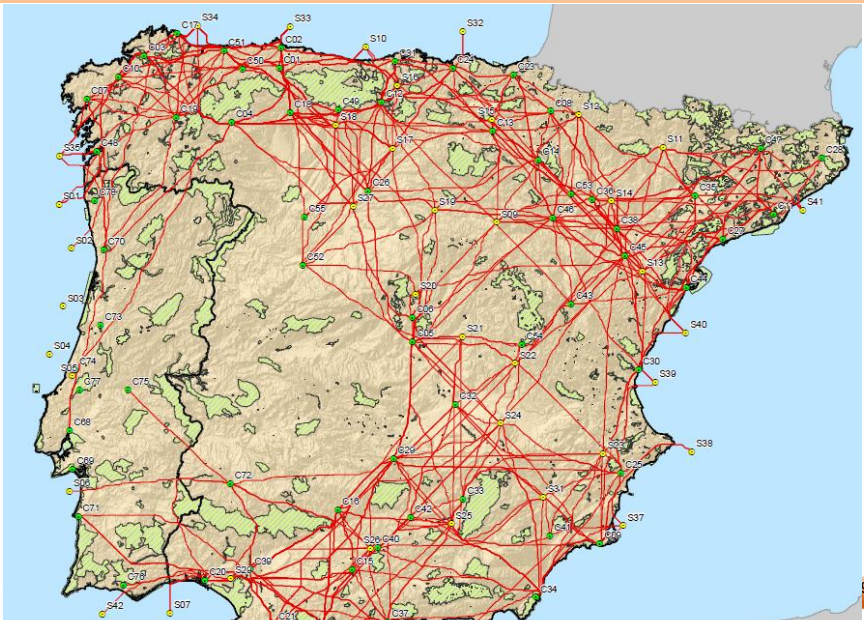
2.2 Sinks: location of 43 clusters



2.2 Sink clusters regions: storage model



2.3 The CO2 transport network



2.3 CO2 transport routes: pipelines model

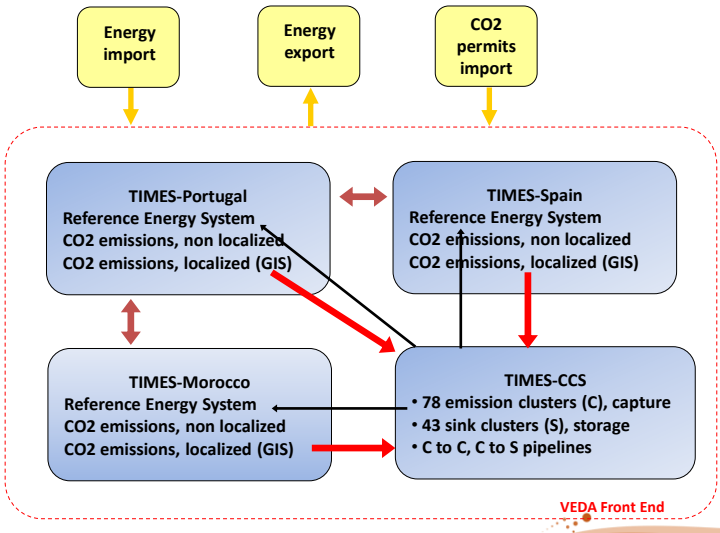
Criteria used to select viable pipelines:

- The cluster with the lowest emissions are not connected to any other cluster, and do not capture (in the final runs the threshold was 0.25 MtCO2/a, and eliminated 21 clusters; 12 would be eliminated with a threshold of 0.15 MtCO2/a)
- Each emission cluster has to be connected to at least one storage cluster, and each storage cluster has to be connected to at least two emission clusters.
- Each emission cluster can send emissions only through the pipelines with unit investment cost lower than a dynamically specified threshold (base Cut-off value for links: 13 Euro/t, adjusted to lower or higher values when the number of routes is too high or too small)
- The same cost criteria is used to select the cheapest emission clusters to emission clusters routes

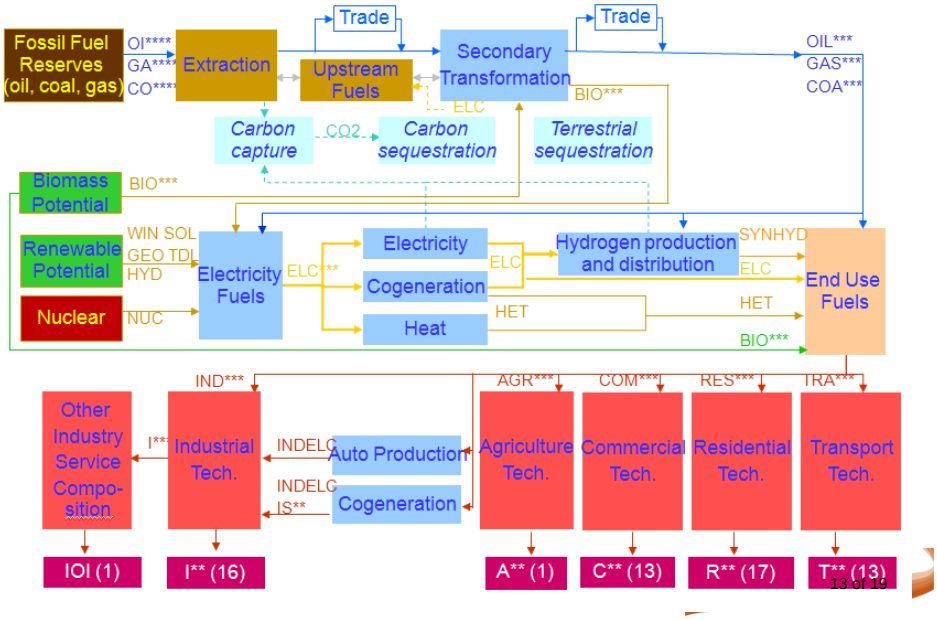
3. Hard-linking the component models into TIMES-COMET

The problem:

- Linking 3 energy country models to
- a model with hundreds of regions
- inside the three country models.



3.1 Reference Energy System of each national models



3.2 Hard-linkage: from the national models … (1/3)

Step 1:

the national CO2 emissions from the sectors that are part of the localised emissions are set to zero in the national models, by setting to zero the value of parameters FLO_EMIS of the four fossil fuel groups:

- from power plants and CHP to the CO2 emitted in the electric sector,
- from refineries to the CO2 emitted in the supply sectors, and
- from the industrial sectors that have geographically defined emissions (cement, glass, iron & steel, pulp & paper, and other sectors).

This results in reducing the country model emissions of the amounts that are emitted by geographically localised emission sources.

CCS technologies existing in the country models, if any, are removed.

3.2 Hard-linkage: … to the emission clusters … (2/3)

Step 2: for the five fuel groups the same emission parameters FLO_EMIS are defined on the commodities directed to the emission regions. This step includes sending the CO2 generated during the cement production processes to the emission regions instead of the country regions. The CO2 emissions directed to the emission regions develop over time differently in each scenario, depending on the developments by sector, fuel and technology in each country model.

Step 3: the emissions produced in each country are allocated to the emission regions located in each country. The information by cluster and sector is available in the base years (2005-10); in the time horizon to 2050 it has been assumed that most clusters develop at the same pace. In other words it is assumed that by sector the share of emissions in each cluster remains the same as it was in the calibration years, within the limits imposed by a user defined relaxation factor.

3.2 Hard-linkage: … via many user constraints (3/3)

This mechanism is implemented by means of a large set of user constraints, as many as the emission cluster regions (78) multiplied by the number of industrial sectors emitting in each cluster. Each user constraint sets a lower bound to the share of national emissions in the sector SEC that has to be allocated in the emission region Crr. The sum of these share lower bounds is close to one (the value in the test runs was 0.999), in order to avoid large shifts to the emission cluster regions where CCS is most economically effective.

The first two steps are implemented in the country models, the last one in the TIMES-CCS model. The three models – TIMES-Iberia, TIMES-Morocco, and TIMES-CCS, each one modified as explained above – are compiled separately and hard-linked at run time. This produces a unique model matrix. The unique solution is processed and all the results can be browsed as usual in the VEDA-BE interface or with the newly developed TSViewer.

4. The TSViewer: options to visualize input/output on a map

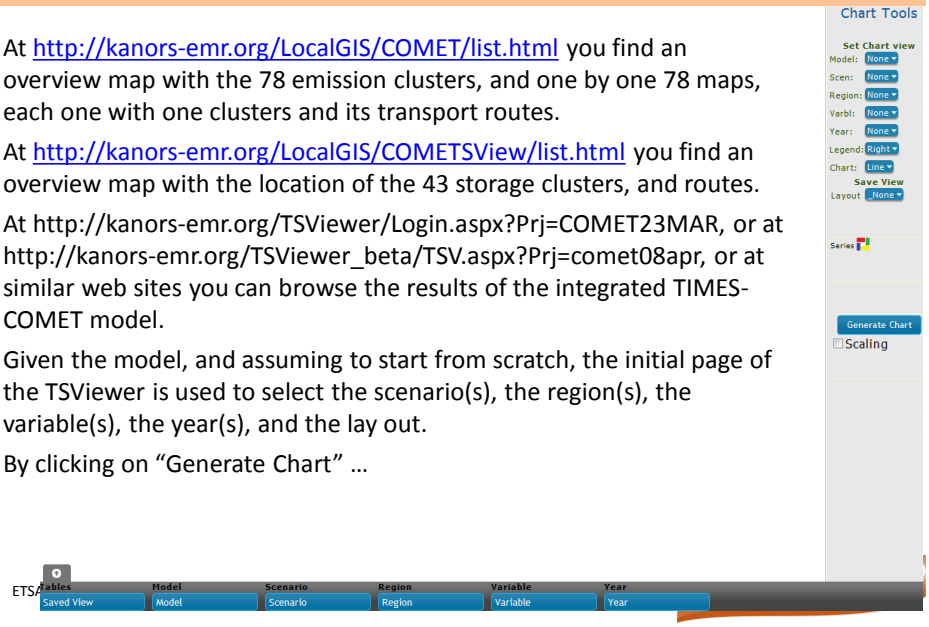
At http://kanors-emr.org/LocalGIS/COMET/list.html you find an overview map with the 78 emission clusters, and one by one 78 maps, each one with one clusters and its transport routes.

At http://kanors-emr.org/LocalGIS/COMETSView/list.html you find an overview map with the location of the 43 storage clusters, and routes.

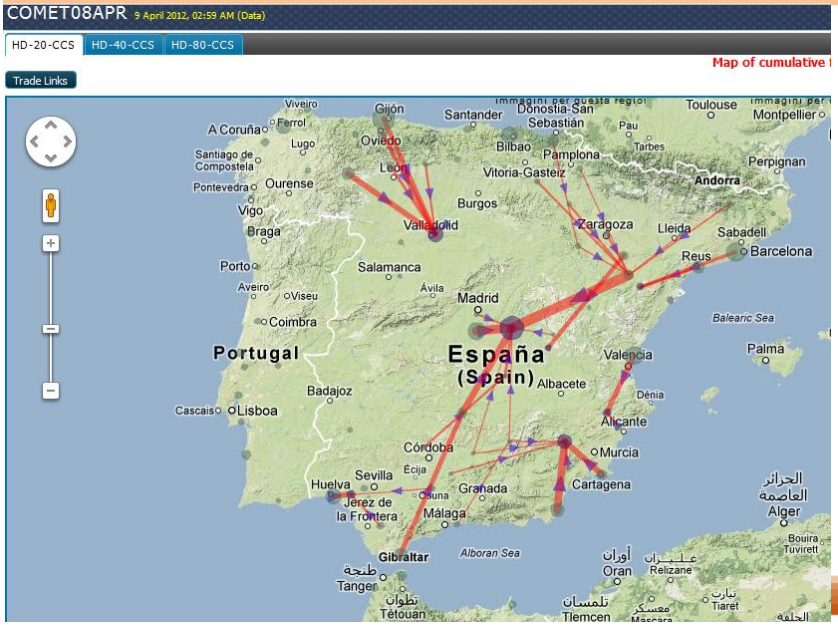
At http://kanors-emr.org/TSViewer/Login.aspx?Prj=COMET23MAR, or at http://kanors-emr.org/TSViewer_beta/TSV.aspx?Prj=comet08apr, or at similar web sites you can browse the results of the integrated TIMES-COMET model.

Given the model, and assuming to start from scratch, the initial page of the TSViewer is used to select the scenario(s), the region(s), the variable(s), the year(s), and the lay out.

By clicking on “Generate Chart” …



4. Geographical presentation of the results in the TSViewer



Click on a cluster or an arrow to visualise related numerical values, or select the option to list all the data by cluster / pipeline

4. Other results displayed by the TSViewer